Helpful Information

The following information is provided to assist the reader in understanding this report. Definitions of technical terms can be found in Appendix B, "Glossary." A public information summary document is available and may be obtained by following the directions given in the "Preface."

Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, by using scientific notation, written as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from its current location. If the value given is 2.0×10^3, the decimal point should be moved three places to the **right** so that the number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five places to the **left** so that the result would be 0.00002.

Units of Measurement

The primary units of measurement used in this report are metric. Table H.1 summarizes and defines the terms and corresponding symbols (metric and nonmetric). A conversion table is also provided in Table H.2.

Table H.1. Names and Symbols for Units of Measure

Symbol	Name	Symbol	Name
Temperature		**Length**	
°C	degree Celsius	cm	centimeter (1×10^{-2} m)
°F	degree Fahrenheit	ft	foot
Time		in.	inch
d	day	km	kilometer (1×10^3 m)
h	hour	m	meter
min	minute	mi	mile
s	second	mm	millimeter (1×10^{-3} m)
yr	year	µm	micrometer (1×10^{-6} m)
Rate		**Area**	
cfs (or ft^3/s)	cubic foot per second	ha	hectare (1×10^4 m^2)
gpm	gallon per minute	km^2	square kilometer
mph	mile per hour	mi^2	square mile
Volume		ft^2	square foot
cm^3	cubic centimeter	**Mass**	
ft^3	cubic foot	g	gram
gal	gallon	kg	kilogram (1×10^3 g)
L	liter	mg	milligram (1×10^{-3} g)
m^3	cubic meter	µg	microgram (1×10^{-6} g)
mL	milliliter (1×10^{-3} L)	ng	nanogram (1×10^{-9} g)
yd^3	cubic yard	lb	pound
		wt%	weight percent
		Concentration	
		ppb	parts per billion
		ppm	parts per million

Table H.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
gal	3.785	L	L	0.2642	gal
ft^2	0.093	m^2	m^2	10.76	ft^2
acre	0.405	ha	ha	2.47	acres
mi^2	2.59	km^2	km^2	0.386	mi^2
yd^3	0.7646	m^3	m^3	1.308	yd^3
nCi	0.001	pCi	pCi	1,000	nCi
pCi/L	10^{-9}	µCi/mL	µCi/mL	10^{9}	pCi/L
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
becquerel	2.7×10^{-11}	curie	curie	3.7×10^{10}	becquerel
becquerel	27	pCi	pCi	0.03704	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1,000	ppb
°F	(°F -32) ÷ 9/5	°C	°C	(°C x 9/5) + 32	°F
g	0.035	oz	oz	28.349	g
metric ton	1.1	ton	ton	0.9078	metric ton

Radioactivity Units

Much of this report deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of curies (Ci) (Table H.3). The curie is the basic unit used to describe the amount of radioactivity present, and activites are generally expressed in terms of fractions of curies in a given mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. In some instances in this report, radioactivity values are expressed with two

Table H.3. Names and Symbols for Units of Radioactivity

Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
µCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)
aCi	attocurie (1×10^{-18} Ci)
Bq	becquerel

sets of units, one of which is usually included in parentheses or footnotes. These units belong to the International System of Units (SI), and their inclusion in this report is mandated by DOE. SI units are the internationally accepted units and may eventually be the standard for reporting radioactivity and radiation dose in the United States. The basic unit for discussing radioactivity, the curie, can be converted to the equivalent SI unit, the becquerel (Bq), by multiplying the number of curies by 37 billion. The becquerel is defined as one nuclear disintegration per second.

Radiological Dose Units

The amount of ionizing radiation energy absorbed by a living organism is expressed in terms of radiological dose. Radiological dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of millirem (mrem) or in the SI unit millisievert (mSv) (Table H.4). Millirem (millisievert) is a term that relates ionizing radiation and biological effect or risk (to humans). A dose of 1 mrem (0.01 mSv) has a biological effect similar to the dose received from an approximate 1-d exposure to natural background radiation. An acute (short-term) dose of 100,000 to 400,000 mrem (1,000 to 4,000 mSv) can cause radiation sickness in humans. An acute dose of 400,000 to 500,000 mrem (4,000 to 5,000 mSv), if left untreated, results in death approximately 50% of the time. Exposure to lower amounts of radiation (1,000 mrem [10 mSv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 300 mrem (3 mSv). Medical and dental x-rays and air travel add to this total. (See Section 5.0.6, "Hanford Public Radiological Dose in Perspective," for a more in-depth discussion of risk comparisons.) To convert the most commonly used dose term in this report, the millirem, to the SI equivalent, the millisievert, multiply millirem by 0.01. The unit "rad," for radiation absorbed dose, or the SI unit, gray (Gy), are also used in this report. The rad is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. A roentgen (R) is a measure of radiation exposure with no SI equivalent. Generally speaking, 1 R of exposure will result in an effective dose equivalent of 1 rem (10 mSv).

Additional information on radiation and dose terminology can be found in Appendix B, "Glossary." A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table H.5.

Table H.4. Names and Symbols for Units of Radiation Dose or Exposure

Symbol	Name
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
Sv	sievert
mSv	millisievert (1 x 10^{-3} Sv)
µSv	microsievert (1 x 10^{-6} Sv)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
µR	microroentgen (1 x 10^{-6} R)
Gy	gray

Table H.5. Radionuclides and Their Half-Lives[a]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.35 yr	^{152}Eu	europium-152	13.3 yr
^{7}Be	beryllium-7	53.44 d	^{154}Eu	europium-154	8.8 yr
^{14}C	carbon-14	5,730 yr	^{155}Eu	europium-155	5 yr
^{40}K	potassium-40	1.3 x 10^{8} yr	^{212}Pb	lead-212	10.6 h
^{51}Cr	chromium-51	27.7 d	^{220}Rn	radon-220	56 s
^{60}Co	cobalt-60	5.3 yr	^{222}Rn	radon-222	3.8 d
^{65}Zn	zinc-65	243.9 d	^{232}Th	thorium-232	1.4 x 10^{10} yr
^{85}Kr	krypton-85	10.7 yr	U or uranium[b]	uranium total	--[c]
^{90}Sr	strontium-90	29.1 yr	^{233}Pa	protactinium-233	27 d
^{95}Zr	zirconium-95	63.98 d	^{234}U	uranium-234	2.4 x 10^{5} yr
^{99}Tc	technetium-99	2.1 x 10^{5} yr	^{235}U	uranium-235	7 x 10^{8} yr
^{103}Ru	ruthenium-103	39.3 d	^{237}Np	neptunium-237	2.14 x 10^{6} yr
^{106}Ru	ruthenium-106	368.2 d	^{238}U	uranium-238	4.5 x 10^{9} yr
^{113}Sn	tin-113	115 d	^{238}Pu	plutonium-238	87.7 yr
^{125}Sb	antimony-125	2.8 yr	^{239}Pu	plutonium-239	2.4 x 10^{4} yr
^{129}I	iodine-129	1.6 x 10^{7} yr	^{240}Pu	plutonium-240	6.5 x 10^{3} yr
^{131}I	iodine-131	8 d	^{241}Pu	plutonium-241	14.4 yr
^{134}Cs	cesium-134	2.1 yr	^{241}Am	americium-241	432.2 yr
^{137}Cs	cesium-137	30 yr			

(a) From Shleien (1992).
(b) Total uranium may also be indicated by U-natural (U-nat) or U-mass.
(c) Natural uranium is a mixture dominated by uranium-238, thus the half-life is approximately 4.5 x 10^{9} yr.

Chemical and Elemental Nomenclature

The chemical contaminants discussed in this report are listed in Table H.6 along with their chemical (or elemental) names and their corresponding symbols.

Understanding the Data Tables

Total Propagated Analytical Uncertainty (2-Sigma Error)

Some degree of uncertainty is associated with all analytical measurements. This uncertainty is the consequence of a series of minor, often unintentional or unavoidable, inaccuracies related to collecting and analyzing the samples. These inaccuracies could include errors associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding. With radionuclides, inaccuracies can also result from the randomness of radioactive decay.

Many of the individual measurements in this report are accompanied by a plus/minus (±) value, referred to as the total propagated analytical uncertainty (or 2-sigma error). For samples that are prepared or manipulated in the laboratory prior to counting (counting the rate of radioactive emissions from a sample), the total propagated analytical uncertainty includes both the counting uncertainty and

Table H.6. Elemental and Chemical Constituent Nomenclature

Symbol	Constituent	Symbol	Constituent
Ag	silver	Hg	mercury
Al	aluminum	K	potassium
As	arsenic	LiF	lithium fluoride
B	boron	Mg	magnesium
Ba	barium	Mn	manganese
Be	beryllium	Mo	molybdenum
Br	bromine	NH_3	ammonia
C	carbon	NH_4^+	ammonium
Ca	calcium	N	nitrogen
$CaCo_3$	calcium carbonate	Na	sodium
CaF_2	calcium fluoride	Ni	nickel
CCl_4	carbon tetrachloride	NO_2^-	nitrite
Cd	cadmium	NO_3^-	nitrate
$CHCl_3$	trichloromethane	Pb	lead
Cl^-	chloride	PO_4^{-3}	phosphate
CN^-	cyanide	P	phosphorus
Cr^{+6}	chromium (species)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO_3^{-2}	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO_4^{-2}	sulfate
F^-	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO_3^-	bicarbonate	V	vanadium

the uncertainty associated with sample preparation and chemical separations. For samples that are not manipulated in the laboratory before counting, the total propagated analytical uncertainty only accounts for the uncertainty associated with counting the sample. The uncertainty associated with samples that are analyzed but not counted includes only the analytical process uncertainty.

The total propagated analytical uncertainty gives information on what the measurement (or result) might be if the same sample were analyzed again under identical conditions. The uncertainty implies that approximately 95% of the time a recount or reanalysis of the same sample would give a value somewhere between the reported value minus the uncertainty and the reported value plus the uncertainty.

If the reported concentration of a given constituent is smaller than its associated uncertainty (e.g., 40 ± 200), the sample may not contain that constituent. Such low-concentration values are considered to be below detection, meaning the concentration of the constituent in the sample is so low that it is undetected by the method and/or instrument. In this situation, the total propagated analytical uncertainty is assumed to be the nominal detection limit.

Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, mean values (averages) are accompanied by ±2 times the standard error of the calculated mean (±2 standard error of the mean). If the data fluctuate randomly, then two times the standard error of the mean is a measure of the uncertainty in the estimated mean of the data from this randomness. If trends or periodic (e.g., seasonal) fluctuations are present, then two times the standard error of the mean is primarily a measure of the variability in the trends and fluctuations about the mean of the data. As with total propagated analytical uncertainty, two times the standard error of the mean implies that approximately 95% of the time the next calculated mean will fall somewhere between the reported value minus the standard error and the reported value plus the standard error.

Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value when all the values are arranged in order of increasing or decreasing magnitude. For example, the median value in the series of numbers, 1 2 3 3 4 5 5 5 6, is 4. The maximum value would be 6 and the minimum value would be 1. Median, maximum, and minimum values are reported when there are too few analytical results to accurately determine the mean with a ± statistical uncertainty or when the data do not follow a bell-shape (i.e., normal) distribution.

Negative Numbers

There is always a small amount of natural radiation in the environment. The instruments used in the laboratory to measure radioactivity in Hanford Site environmental media are sensitive enough to measure the natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the natural, or background, radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions and the very low activities of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

Understanding Graphic Information

Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs make it easy to visualize differences in data where they exist. However, while graphs may make it easy to evaluate data, they also may lead the reader to incorrect conclusions if they are not interpreted correctly. Careful consideration should be given to the scale (linear or logarithmic), concentration units, and type of uncertainty used.

Some of the data graphed in this report are plotted using logarithmic, or compressed, scales. Logarithmic scales are useful when plotting two or more numbers that differ greatly in size. For example, a sample with a concentration of 5 g/L would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 1,000 g/L (Figure H.1). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure H.2).

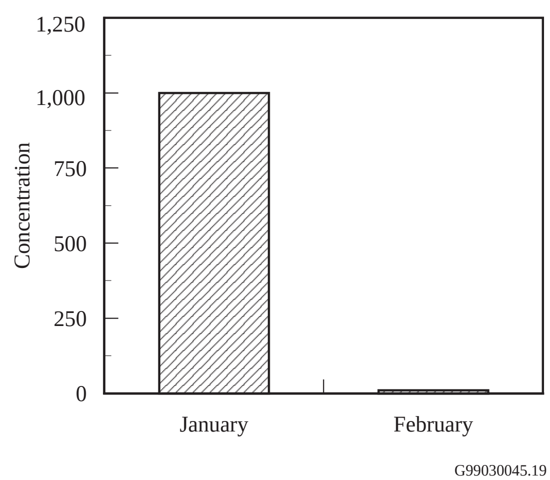

Figure H.1. Data Plotted Using a Linear Scale

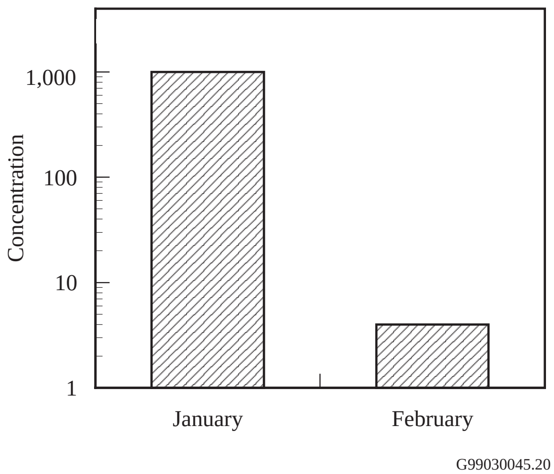

Figure H.2. Data Plotted Using a Logarithmic Scale

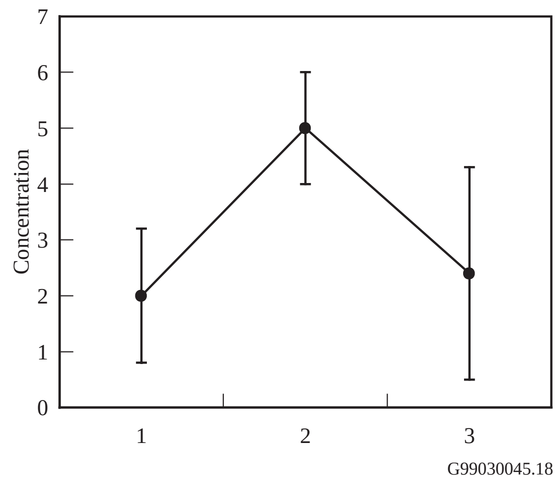

Figure H.3. Data with Error Bars Plotted Using a Linear Scale

The mean (average) and median (defined earlier) values graphed in this report have vertical lines extending above and below the data point. When used with a mean value, these lines (called error bars) indicate the amount of uncertainty (total propagated analytical uncertainty or two standard error of the mean) in the reported result. The error bars in this report represent a 95% chance that the mean is between the upper and lower ends of the error bar and a 5% chance that the true mean is either lower or higher than the error bar.[(a)] For example, in Figure H.3, the first plotted mean is 2.0 ± 1.1, so there is a 95% chance that the true mean is between 0.9 and 3.1, a 2.5% chance that it is less than 0.9, and a 2.5% chance that it is greater than 3.1. Error bars are computed statistically, employing all of the information used to generate the mean value. These bars provide a quick, visual indication that one mean may be statistically similar to or different from another mean. If the error bars of two or more means overlap, as is the case with means 1 and 3 and means 2 and 3, the means may be statistically similar. If the error bars do not overlap (means 1 and 2), the means may be statistically different. Means that appear to be very different visually (means 2 and 3) may actually be quite similar when compared statistically.

When vertical lines are used with median values, the lower end of each bar represents the minimum concentration measured; the upper end of each bar represents the maximum concentration measured.

Greater Than (>) or Less Than (<) Symbols

Greater than (>) or less than (<) symbols are used to indicate that the actual value may either be larger than the number given or smaller than the number given. For example, >0.09 would indicate that the actual value is greater than 0.09. An inequality symbol pointed in the opposite direction (<0.09) would indicate that the number is less than the value presented. An inequality symbol used with an underscore (≤ or ≥) indicates that the actual value is less than or equal to or greater than or equal to the number given, respectively.

(a) Assuming a normal statistical distribution of the data.

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